جامعة بيروت العربية
BEIRUT ARAB UNIVERSITY

Fountain View Residence

CVLE 564 – Quality Control

By

Jana Shmaysem – 201902096

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Department of Civil and Environmental Engineering

Faculty of Engineering

Supervisor

Dr. Mohamad Dandachi

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Tripoli Campus

Abstract

Following a fire, the first structural concern is whether the structure can be renovated or, in the worst-case scenario, needs to be replaced. The course of action must be determined by an assessment of the structure's condition. This estimate is based on a mapping of the construction's damage. Damage mapping must be precise in order to improve both the degree of safety and be the most cost-effective solution. The work given in this report is about structure restoration technique and generally used traditional testing methods to establish Fountain View residence and to undertake such a "mapping of damage" to determine the project's structural stability. The rebound hammer, compressive strength, ultrasonic pulse measurements, and Petography technique are among the conventional assessment methods included in the experimental section of the report. On drilled cores of undamaged oncrete, they are compared to optical full-field strain measurements during a compressive stress cycle. Based on the findings, we should create a visual map of the damage, including spalling, cracking, delaminations, deformations, and other physical effects caused by the fire, in order to fix the building's stability.

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CHAPTER 1 INTRODUCTION

The Address Residence Fountain Views is a multi-building complex located in Dubai's Downtown district. The Address Residence Fountain Views 2, The Address Residence Fountain Views 3, and The Address Residence Fountain Views 1 are the three buildings that make up the development. In 2012, work on the project began. Emaar Properties was in charge of the project's development. Dewan Architects & Engineers was the project's architect.

Figure 1:Fountain View Residence[5]

Emaar Properties PJSC has chosen BuroHappold Consulting Engineers Limited to conduct an independent structural condition assessment of The Address Fountain Views Development as a result of the fire occurrences on April 2, 2017.

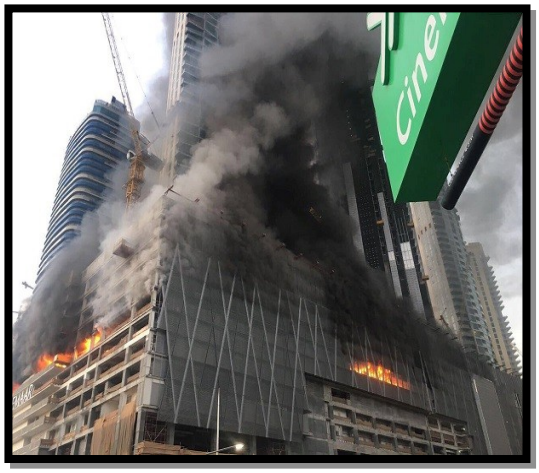


Figure 2:Fountain View on fire[5]

It's critical to establish the damaged structure's residual strength and serviceability at this stage after the fire, so that recommendations for repairs can be made.
The goal of this document is to describe the minimal expected scope of work and give a testing schedule so that testing agencies can submit proposals for in-situ and laboratory testing of the existing structure as specified in this study.

1.1 Project Brief

The Address Fountain Views is a construction across the street from the Dubai Mall, one of Dubai's most prestigious shopping venues, which draws a large number of tourists and a lot of media attention. Emaar Properties PJS is building the project as a direct link to the Dubai Mall and an extension of Emaar Boulevard.

1.2 Fire Event

According to the information provided, the fire started about 4.30 a.m. on April 2, 2017. The fire started on podium level P6, Plot 112 of the development, which is located towards the project's northern end. According to our understanding, P6 level was used as a temporary storage location for joinery materials (doors and wood cabinets).

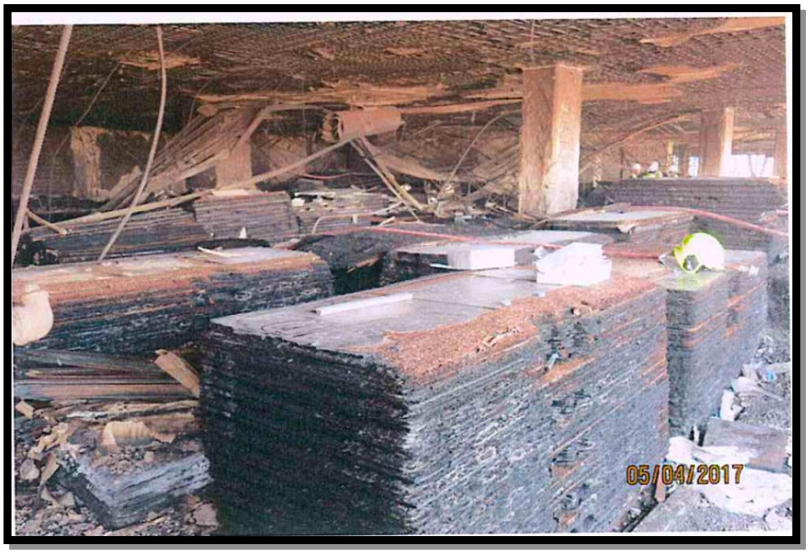


Figure 3:Fire load material[3]

After four hours, the fire was said to have been extinguished the next morning.
The material was stacked to a height of roughly 1 to 1.5 metres, as shown in Figure 1-1. As a result, the fire flame was closer to the ceiling, causing the P7 slab to sustain substantially more damage than vertical features such as walls and columns.

On the 5th, 9th, and 10th of April, BuroHappold visited the site and conducted a visual assessment of all accessible areas. We plan more site visits to complete the inspection of the L6 slab and inaccessible regions such as the P7 level since debris and burned stored stuff have not been removed from the site.
Our preliminary findings from the three-day site visit suggest that the structure damage is contained north of the expansion joint at axis P-34, within level P6, including the floor slab of level P7. See Figure 1-3 for more information.

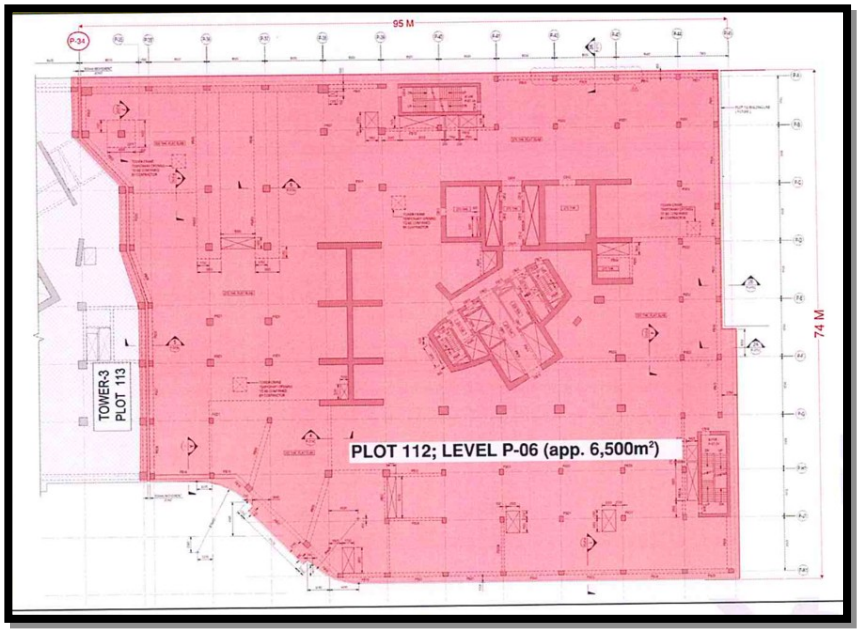


Figure 4:Plot of the area damaged by fire[3]

1.3 Aims

This report aims to provide an overview of some traditional methods for assessing damage to concrete cross-sections after a fire, determine the residual strength and serviceability of the damaged material by testing the damaged concrete using quality control procedures, and outline the necessary repairs.

1.4 Codes and standards

These are the list of codes and standards used in this project.

Table 1:List of codes and figures used in this project

ACI 318M 11	Building Code Requirements for Structural Concrete
ACI 506R	Guide to Shotcrete
ACI 506.2	Specifications for Shotcrete
ACI RAP 12	Concrete Repair by Shotcrete Application
ACI 562-16	Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures and Commentary.
ACI 201.1R	Guide for Making a Condition Survey of Concrete in Service
ACI 201.2R	Guide to Durable Concrete
ACI 207.1R	Guide to Mass Concrete
ACI 207.2R	Effect of Restraint, Volume Change, and Reinforcement on Cracking of Mass Concrete
ACI 207.3R	Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions
ACI 224R	Control of Cracking in Concrete Structures
ACI 224.2R	Cracking of Concrete Members in Direct Tension
ACI 228.2R	Non-destructive Test Methods for Evaluation of Concrete in Structures
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 546R	Concrete Repair Guide
ACI 503R	Use of Epoxy Compounds with Concrete
ACI 504R	Guide to Sealing Joints in Concrete Structures
ACI RAP-1	Structural Crack Repair by Epoxy Injection
ACI 562-16	Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures and Commentary.

ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C1140	Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels
ASTM C1141	Standard Specification for Admixtures for Shotcrete
ASTM C1583	Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
ASTM C42	Standard method for obtaining and testing drilled cores of concrete
ASTM C469	Standard method test for static modulus of elasticity and poisons ratio of concrete in compression.
ASTM 642	Standard test method for density ,Absorption, and voids in hardened concrete
ASTM E178	Standard practice for dealing with outlying observation.
ASTM C295	Standard guide for petrographic examination of aggregates for concrete
ASTM C856	Standard practice for petrograohic examination of hardened concrete
ASTM C1723	Standard guide for examination of hardened concrete using scanning Electron Microscopy
ASTM A370	Standard test methods and definitions for mechanical testing of Steel Products
ASTM E6-09BE1	Standard terminology related to methods of mechanical testing
ASTM E8/E8M	Standard test method for tension testing of Metallic Materials.
ACI 214R.4R	Guide for obtaining cores and interpreting compressive strength Results.
ACI 364.1R	Guide for obtaining Cores and

	interpreting Compressive strength Results.
NFPA 241	Standard for Safeguarding Construction, Alteration and Demolition Operations – National Fire Protection Association.
ICRI 120.1	Guidelines and Recommendations for Safety in the Concrete Repair Industry.

1.5 Project description

SPME's Construction Management Team will oversee and manage the construction site activities (CMT). All engineering and construction activities for the project installations will be coordinated by the CMT. The CMT will ensure that the Work is completed safely, on time, and to the highest possible standard of quality in all areas.

This will include but not be limited to:

- Supervision and Management
- Construction Engineering
- Health Safety environment
- Material Management
- Planning, Progress Control and Reporting
- Inspection and Testing, Completion and Handover

The project will be given special attention, and SPME will enlist the help of qualified professionals, including experts with relevant experience, demonstrated leadership, and technical expertise. The project's

requirements are prepared in advance and will be deployed on short notice and in a timely manner.

CHAPTER 2 PLANING, MANAGEMENT AND QUALITY CONTROL

This chapter explains how SPME plans, manages, and executes work during the current project phase. All concrete repair and strengthening work on the Fountain View Project is covered within this chapter. It outlines the project's obligations and quality assurance procedures.

This paper relates to concrete repair and strengthening projects in the following areas:

- Tower and podium columns at level 07
- Tower and podium columns and walls at level 06
- Cosmetic repairs which are done in parallel with other repairs.

Most fire-damaged structures may be successfully repaired, which is a more cost-effective option than demolition and reconstruction.

2.1. Responsibility

The construction manager is in charge of the overall implementation and making sure that the section engineer, site engineer, and general foremen are aware of the requirements. He is in charge of:

- Controlling the coordination between all involved parties to ensure safety, quality, and schedule criteria are satisfied
- providing the essential resources in terms of labour, equipment, and material.

The Section Engineer's responsibilities include:

- controlling and ensuring that the construction work is carried out in accordance with the Method Statement;
- ensuring that all essential resources in terms of labour, equipment, and material are available.

The quality manager is in charge of:

- Ensuring that all inspection-related activities are documented and cleared by the consultant.
- Overseeing and coordinating with a third-party laboratory to conduct required testing in accordance with standard requirements, as well as testing and reporting to the Engineers.

The Quality Engineer is in charge of:

- Inspecting and ensuring that all testing is completed in accordance with the relevant Standard, specification, and authorised method statement.

- Notifying the consultant when his presence is required for the inspection to be completed

- Going on the inspection with the consultant to release the hold points.

2.2. Quality Assurance and Quality control

2.2.1. Project Quality Policy Brief

It is SPME policy that all repair materials are to be of the highest standard and the works are to be supervised and carried out in accordance with the contract requirements, applicable standards and codes of practice by suitably qualified and skilled personnel.

2.2.2. Procedures Quality Plan

All repair materials must meet the highest standards, and the work must be monitored and completed by adequately qualified and skilled staff in line with the contract requirements, applicable standards, and codes of practise.

The project's Project Manager, Project Engineer, Construction Manager, and/or Superintendent will be in charge of the project's planning and implementation of works. SPME will implement and perform the quality control functions necessary to ensure and document that the work is completed in accordance with the Contract.

Team training: undertake work-related training programmes, including but not limited to the following:

- Examine the existing structure's structural load restrictions.
- Examine the criteria for temporary bracing.
- Examine the requirements for repairs conducted by other trades.
- The project's conditions
- Before beginning repair work, notify the consultant of any differences between the existing circumstances and the plans.
- Hazardous Materials: It is unknown whether hazardous materials shall be encountered in the Work.
- Maintain fire-protection facilities in service during repair operations.

2.2.3. Quality Control

All operations that have an impact/effect on the quality of the job are covered by the site quality control inspections. The project QC Team inspects the craftsmanship of these actions and documents it in quality check records.

The surface finish was specified as CSP (Concrete Surface Profile) = 8 (scabbled), which is in accordance with ICRI Guideline No. 310.2R-2013, which states that the surfaces must be prepared as "rough" with at least 3 mm roughness at a depth of roughly 40 mm.

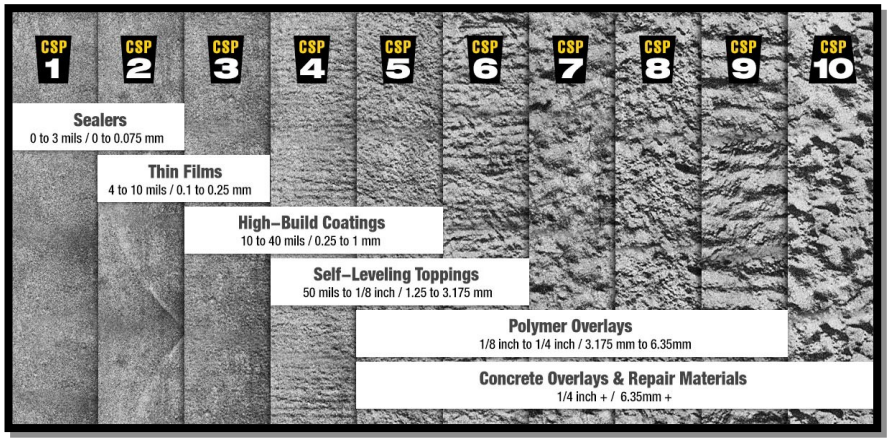

CSP 1
CSP 2
CSP 3
CSP 4
CSP 5
CSP 6
CSP 7
CSP 8
CSP 9
CSP 10
Sealers
0 to 3 mils / 0 to 0.075 mm
Thin Films
4 to 10 mils / 0.1 to 0.25 mm
High–Build Coatings
10 to 40 mils / 0.25 to 1 mm
Self–Leveling Toppings
50 mils to 1/8 inch / 1.25 to 3.175 mm
Polymer Overlays
1/8 inch to 1/4 inch / 3.175 mm to 6.35mm
Concrete Overlays & Repair Materials
1/4 inch + / 6.35mm +

Figure 5:Concrete surface profile description[6]

Visual inspections using CSP moulded duplicates will be used to verify the surface profile. CSP reproductions can be compared to the actual concrete profile formed during surface preparation. The copies are compared visually after being put on the prepared surface. The profile will fall inside the given parameters. The tensile bond between the repair overlay and the existing concrete substrate will be evaluated using the methods outlined in ASTM D7682 – Replica Putty Pull-off Tensile Bond Test. The Owners Consultant will determine the number and location.

2.3. Materials

The following are the major materials that will be used in this project:

- Mocro concrete
- Concrete sprayed on (shotcrete)

SPME will complete this project's repairs in compliance with industry codes and standards.

CHAPTER 3 TESTING AND REPAIR METHODOLOGY

3.1. Objective

The concrete will be evaluated to verify that repairs and reinstatements address any inherent or pre-existing concerns, such as low covers, excessive chloride levels, or carbonation depths, as well as the consequences of the fire on the structure's long-term durability. The procedures for structural concrete repair with formed and pressure pumped concrete are described in this chapter. It also specifies the procedures for chipping, cutting, and surface preparation of existing concrete before resurfacing with form and pump concrete, shotcrete, or patching.

3.2. Structural Repair Types

Different repair procedures have been utilised for different columns depending on the level of the damage caused by fire. Some columns have been damaged on all four sides, while others have only been damaged on one side and merely require cosmetic restoration, as seen in the 6th level GA plan below.

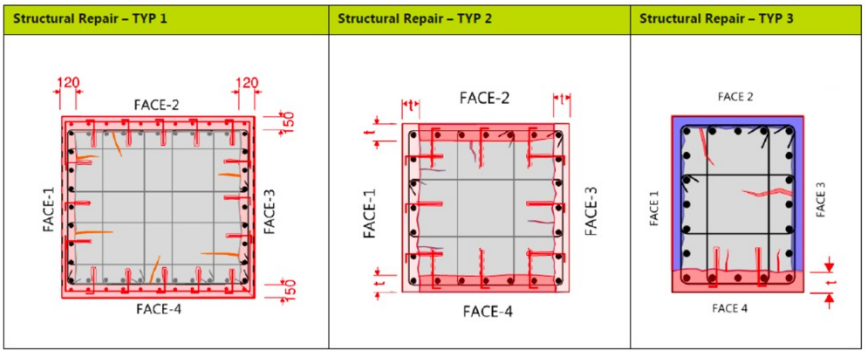


Figure 6:Structural repair Type 1,Type 2,and Type 3[4]

The following is the procedure for repair:

1. Type 1

Damaged columns on all four sides necessitate section enlargement: decreased section considers reduction on two sides while ignoring reinforcement on these sides (remove concrete up to 30mm behind vertical reinforcement with amplitude of 5mm). Furthermore, it accounts for the damage produced by the fire on these two faces by reducing the

section on the other two sides (in the calculations, the section has been lowered for the concrete cover and the link size).

2. Type 2

Similar approaches are performed for broken columns on four sides that require structural repair but not enlargement. Because the repairs are planned to be done on both sides at the same time,

3. Type 3

Reduced section analyses reduction on the damaged side while ignoring reinforcement on the opposite side (remove concrete up to 30 with amplitude of 5mm behind vertical reinforcement). Furthermore, it takes into account reduction on the other sides to account for the fire's damage on these faces.

If a full structural repair is necessary, such as when the new concrete or mortar is expected to carry its full share of the load in the repaired member, propping is required, along with complete load removal.

The following are the primary procedures for repairing fire-damaged concrete in reinforced concrete:

- Replacement of weakened reinforcement
- Removal of damaged or defective concrete
- Concrete replacement to restore the original form while also ensuring structural capacity, durability, and fire resistance. In some cases, the reintroduction of unique finishes and appearance may be required.

Figure 7:Propping in the real structure[1]

3.3. Repairing method for vertical elements

To ensure that the extremely dried out fire damaged concrete meets the requisite saturated surface dry (SSD) requirements, it will be properly soaked with potable water.

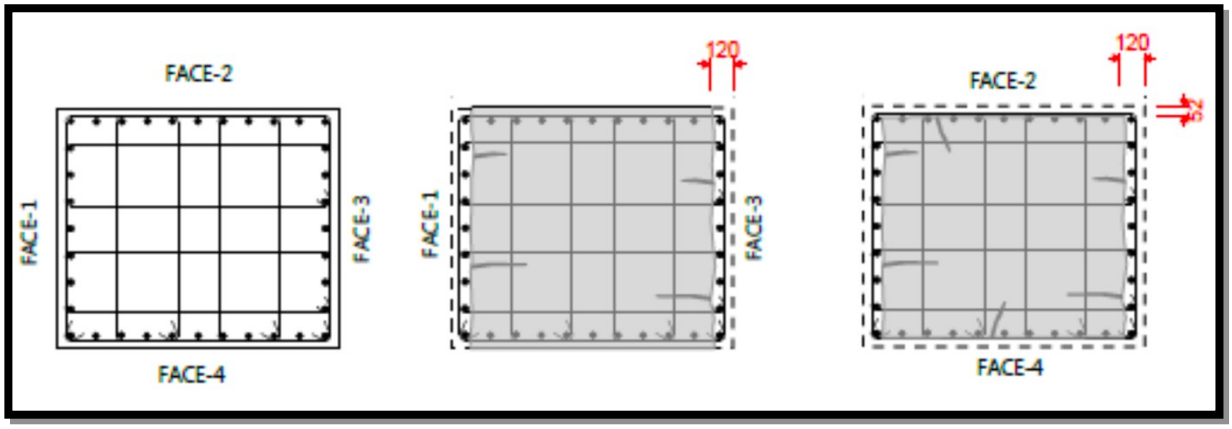


Figure 8:Process of removing damaged concrete[4]

o Remove 30+/5mm of concrete from both sides of the vertical reinforcement.
o Remove the vertical reinforcing concrete covers on faces 2 and 4.
o Use a pressure washer or another acceptable method to clean chipped surfaces.
o After cleaning the chipped surfaces, look for and note any exposed cracks.
o Reinforce face 2 and 4 with outer layer reinforcement.

o Use epoxy glue to anchor shear dowels to the column core.

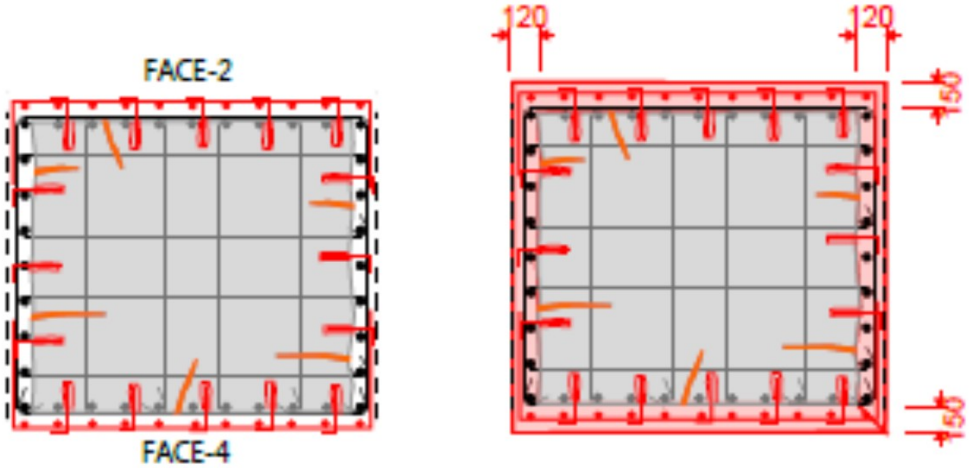


Figure 9:Process of section repairing by enlargement of damaged concrete[4]

Install the outer concrete jacket using the form and pump method, which entails a single operation that includes the exposed reinforcement on faces 1 and 3 as well as the new reinforcement on faces 2 and 4.

After a fire, spalled and blackened concrete surfaces may appear to suggest extensive damage while, in fact, the damage may be far less severe. To evaluate the degree and extent of the fire damage, as well as to qualitatively and statistically define the remaining concrete, an assessment will require a combination of complimentary investigative methodologies.

On-site assessment/investigation efforts on this project include, to the extent necessary, the use of the following techniques:

- visual inspection and evaluation (visual inspection and hammer soundings).
- Non-destructive testing (includes rebound hammer and ultrasonic pulse velocity -UPV)
- Concrete core compressive strength sampling (coring drilling) and subsequent laboratory testing Examination of Petrography

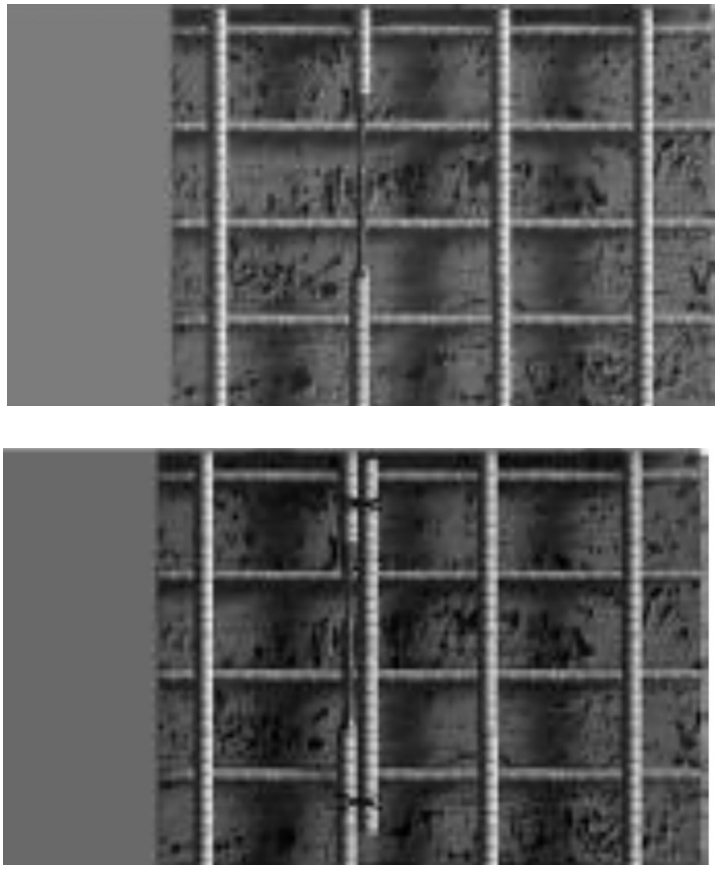


Figure 10:Difference between before and after repairing damaged reinforcement[5]

3.4. WORK PROCEDURES

3.4.1. Identification and Assessment of Fire Affected Areas

After a fire, spalled and blackened concrete surfaces may appear to suggest extensive damage while, in fact, the damage may be far less severe. To evaluate the degree and extent of the fire damage, as well as to qualitatively and statistically define the remaining concrete, an

assessment will require a combination of complimentary investigative methodologies.

On-site assessment/investigation efforts on this project include, to the extent necessary, the use of the following techniques:

- visual inspection and evaluation (visual inspection and hammer soundings).
- Non-destructive testing (NDT) is a type of non-destructive testing that is (including rebound hammer, ultrasonic pulse velocity -UPV)
- Concrete core compressive strength sampling (coring drilling) and subsequent laboratory testing, and Petrography Examination
- reinforcement Mechanical characteristics (bar testing, incl. hardness, natural frequency and stress relaxation testing).

3.4.2. Testing Regime

In order to properly assess the level of structural damage, on-site testing, material sample, and laboratory testing of existing concrete structures are required. The goal of this enquiry is to estimate the depth of the damaged concrete caused by the fire's high temperatures, and then use in-place strengths to assess the compressive strength of the undamaged concrete in the existing building. The results of these tests, as well as their interpretation, will be used to inform the repair approach.

The scope of testing described in this section should be considered the initial minimum required scope of testing to acquire a complete understanding of the concrete structure's current circumstances.
This process' methodology can be summarised and classified as follows:

Drilling, coring, and preservation of core samples until testing begins

- Labeling, photography, documentation, and recording of samples and tests
- In-situ survey
- Non-destructive testing
- Drilling, coring, and preservation of core samples until testing begins

- Labeling, photography, documentation, and recording of samples and tests
- Testing in the field
- In-situ testing
- Laboratory testing

In addition, the survey of the level 07 slab will reveal the slab's deformations/deflections as a result of the fire damage.

3.4.2.1. In-situ survey of level 07 slab

Due to extensive fire damage, concrete spalling, and a deteriorating link between reinforcement and concrete, the majority of the bottom reinforcement in the Podium level 07 slab has been lost. In some places, the reinforcement has entirely collapsed to the level 6 slab, while in others, it is still present but split from the concrete.

The extreme deflection of the level 07 slab was visible and noticeable, as indicated in the diagram below.

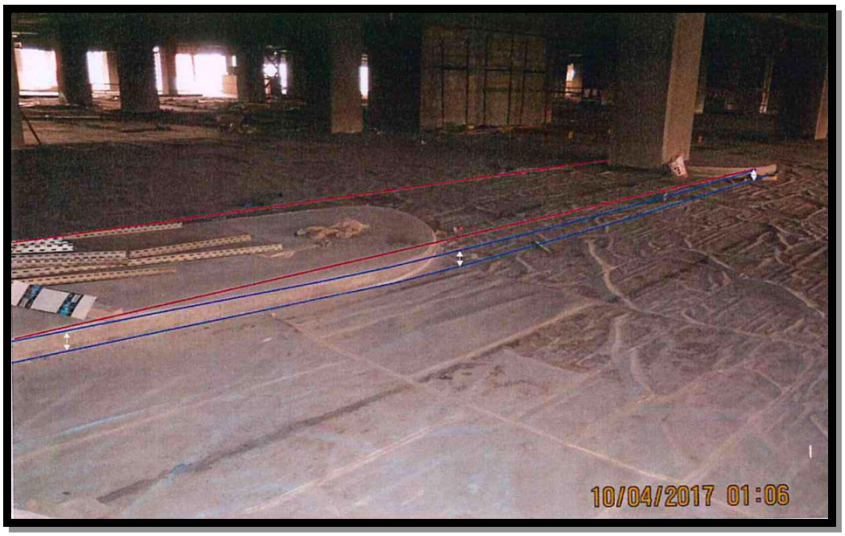


Figure 11:Observed excessive deformation of level 07 slab[3]

3.4.2.2. Hammer Sounding Test

When structural elements are designated as damaged, the Specialist Contractor must inspect them for delamination of the concrete cover to the reinforcement.
Although the concrete surface may exhibit symptoms of crazing, peeling, or slight spalling, it appears to be in good condition.

The use of a hammer should reveal spots where the concrete cover has delaminated and needs to be replaced.
All surfaces identified as weak, i.e. potentially delaminated, must be tagged with spray paint by the contractor, as these places will need to be repaired.

Figure 12:Hammer sounding test[6]

3.4.2.3. Rebound number of hardened concrete

The use of a spring-steel driven Rebound hammer to determine the rebound number of hardened concrete is covered by this test procedure. This test method can be used to determine concrete's in-plane homogeneity, to identify zones of low quality in a structure that has been damaged by fire, and to estimate in-plane strength development.

⇒ Procedure

o Maintain a firm grip on the instrument so that the plunger is perpendicular to the test surface.
o Gently press the instrument against the test surface until the hammer makes contact.
o Maintain pressure on the instrument after impact and, if necessary, depress the side-of-the-instrument button to lock the plunger in its retracted position.
o Round up the rebound number on the scale to the nearest whole number and record it.
o for each test region, take ten readings.

Figure 13:Rebound hammer, a)Spring relaxed, b)spring tensed[6]

3.4.2.4. Concrete Core Compressive Strength (coring)

Testing cores taken from the structure is the most direct means of evaluating the strength of in-situ concrete. The initial step in a number of accessible test methodologies is to extract cores from a fire-damaged structure. The goal of this project is to define a coring procedure for assessing the strength, modulus of elasticity, and durability of hardened concrete at levels affected by a fire incident at Podium areas at locations marked by the Engineer, and to compare the results to cores taken from areas that were not affected by the fire. The cores are installed safely, with minimal impact on strength, and in compliance with the requirements that all quality assurance, control, and inspection activities be carried out in a methodical manner.

Concrete cores are extracted by rotary drilling with a diamond-tipped hollow barrel to obtain a sample of concrete that may subsequently be used to measure a variety of physical parameters, the most common of which is compressive strength. Floors, slabs, walls, and columns are examples of places where cores can be extracted if access is available.

⇒ The Apparatus to be used for testing

- Electrical power core drilling machine
- Drill machine
- Core barrels of suitable diameter
- Extension rods
- Cover meter
- Rod

⇒ Test Procedure

- Preliminary work
  - All test areas must be accessible in a safe manner.
  - Scaffolding with safety tags to be used for coring on higher ground
  - When operating in restricted places, adequate lighting and ventilation must be given.

- Coring Techniques

  - Mark the placement of coring on the walls according to the layout agreed upon by the engineers.
  - Check for reinforcement bars using a cover metre. (Manually remove the lid)
  - Connect the power supply to the drill and attach the needed core barrel.
  - Connect the water pump and make sure there is enough water to keep the core barrel cool.
  - Drill cores perpendicular to the surface, being careful not to harm them.
  - While coring, keep the drill in a rigid posture
  - When the core has reached the desired length, remove it from the hole and discard it.
  - Note the location and orientation of the drill bit within the element from which it was drilled.

- Transportation of cored specimens

Cored specimens should be wrapped in moist hessian and placed in plastic sealed bags before being sent to the lab for testing.

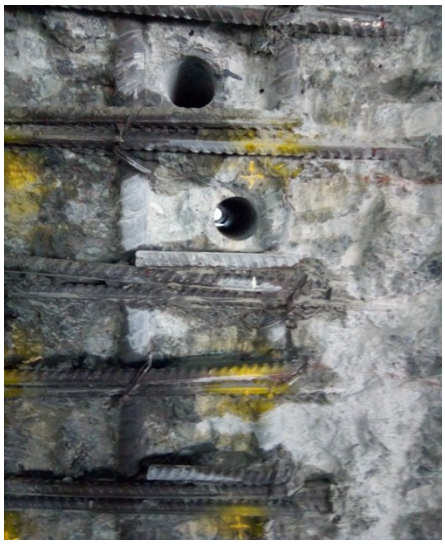


Figure 14:Coring from spalled concrete[1]

Figure 15:Coring from normal concrete without damage[1]

In our situation, the tests are conducted with two core diameters: 100 mm and 75 mm.
Each element must have a minimum of 5 cores.
After the fire-damaged concrete is removed from the concrete core, the ideal length to diameter ratio for compressive strength concrete cores is L/D=1.5-2, which is a 150-200 mm long core of sound, fire-unaffected concrete.
Cores with an L/D of less than one will not be allowed for testing.

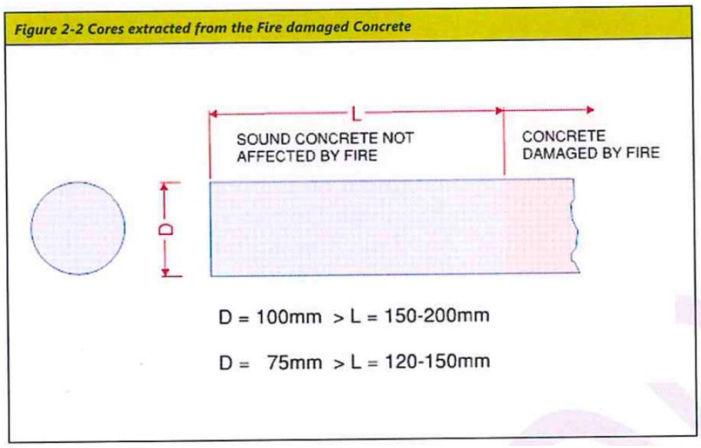


Figure 2-2 Cores extracted from the Fire damaged Concrete
L
SOUND CONCRETE NOT AFFECTED BY FIRE
CONCRETE DAMAGED BY FIRE
D
D = 100mm > L = 150-200mm
D = 75mm > L = 120-150mm

Figure 16:Core extracted from the fire damaged concrete[3]

Figure 17:Real application of coring concrete samples from a wall[1]

Cores with a diameter of 100 mm are preferable. That, however, is dependent on the structure's position, reinforcement congestion, and the thickness or depth of the studied portion. Smaller diameter cores are better for shallower concrete cores, while larger diameter cores (100mm) are better for longer/deeper concrete cores.

- ⇒ Extracting cores from fire-damaged concrete in the field entails the following:
    - Cores with a diameter of 100mm - the minimum length of a core, including fire-damaged concrete, should be 250-300mm.
    - 75mm dia. cores - minimum core length should be 180-220mm, including fire damaged concrete.
- ⇒ Extracting cores from non-fire-damaged concrete in the field entails the following:
    - 100mm diameter cores - minimum core length should be 200-250mm

- 75mm diameter cores - minimum core length should be 150-200mm

Figure 18:Standard cubes concrete testing [1]

- Extracting the cores of the structure

The symbols and names indicated on the drawings for extracting and naming the specimens for various tests depict the convection.

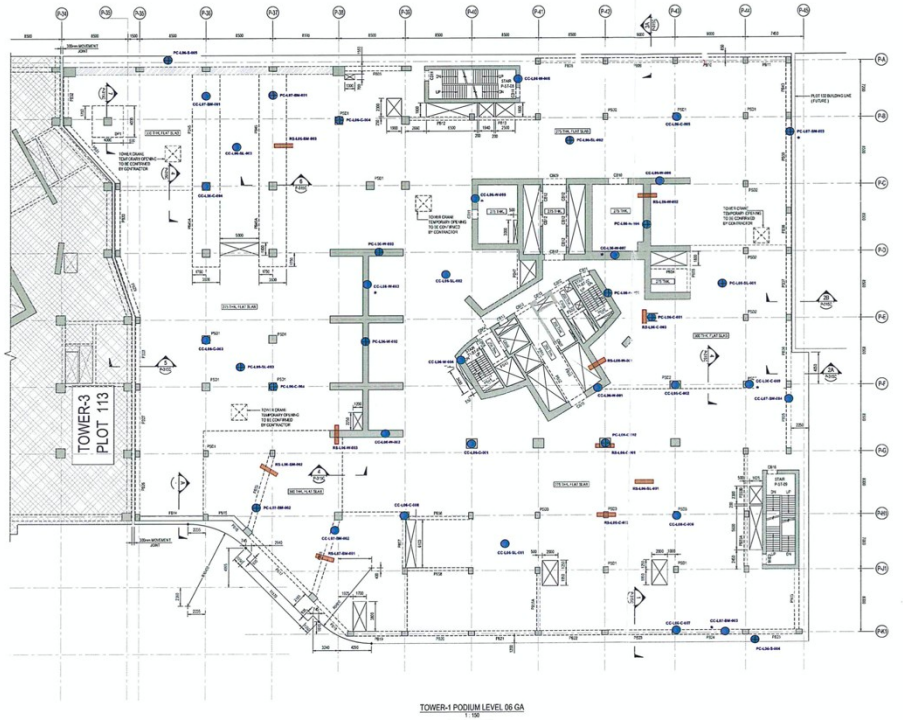


Figure 19:Plot of the locations specified for coring[3]

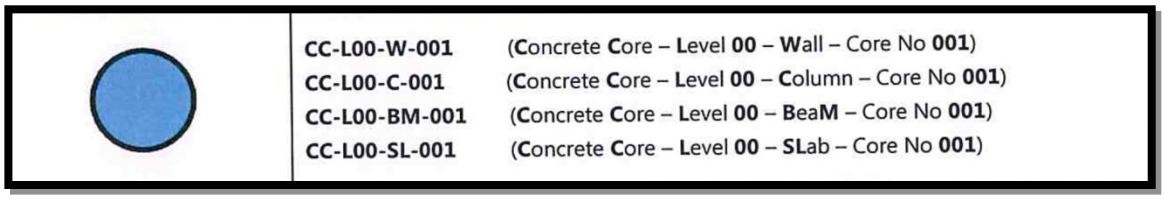

CC-L00-W-001 (Concrete Core – Level 00 – Wall – Core No 001)
CC-L00-C-001 (Concrete Core – Level 00 – Column – Core No 001)
CC-L00-BM-001 (Concrete Core – Level 00 – BeaM – Core No 001)
CC-L00-SL-001 (Concrete Core – Level 00 – SLab – Core No 001)

Figure 20:Legend for the coring plot for Compressive and UPV test[3]

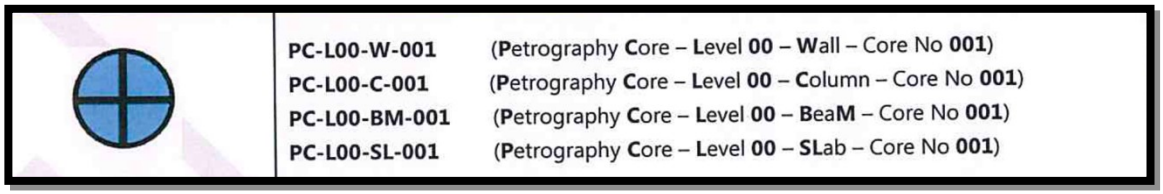

PC-L00-W-001 (Petrography Core – Level 00 – Wall – Core No 001)
PC-L00-C-001 (Petrography Core – Level 00 – Column – Core No 001)
PC-L00-BM-001 (Petrography Core – Level 00 – BeaM – Core No 001)
PC-L00-SL-001 (Petrography Core – Level 00 – SLab – Core No 001)

Figure 21:Legend for the coring plot for Petrography analysis[3]

RS-L00-W-001 (Reinforcement Sample – Level 00 – Wall – Sample No 001)
RS-L00-C-001 (Reinforcement Sample – Level 00 – Column – Sample No 001)
RS-L00-BM-001 (Reinforcement Sample – Level 00 – BeaM – Sample No 001)
RS-L00-SL-001 (Reinforcement Sample – Level 00 – SLab – Sample No 001)

Figure 22:Legend for the coring plot for Reinforcement specimen[3]

Prior to each drilling, a rebar cover metre test must be performed to record the concrete cover given in the local region as well as to locate the drillings to prevent hitting reinforcement bars whenever possible.

Figure 23:Locating Reinforcement and recording Cover using Hilti PS-35 Ferrodetector[3]

The figures below provide examples of typical core extraction positions from columns and wall elements.

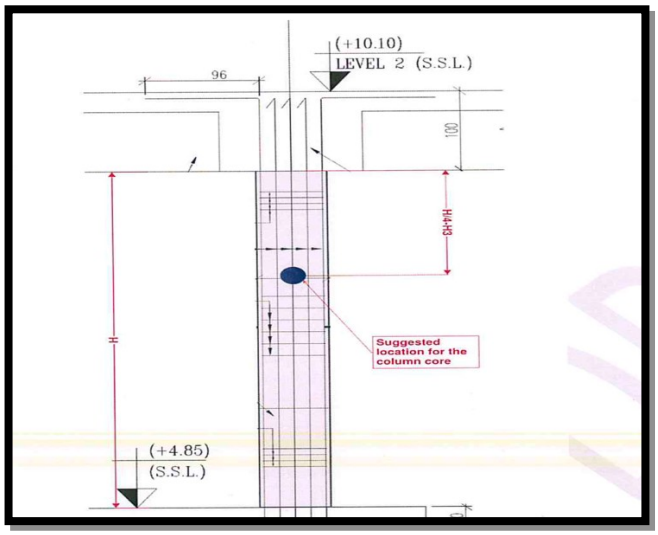


Figure 24:Typical Location of core sample taken from a column[3]

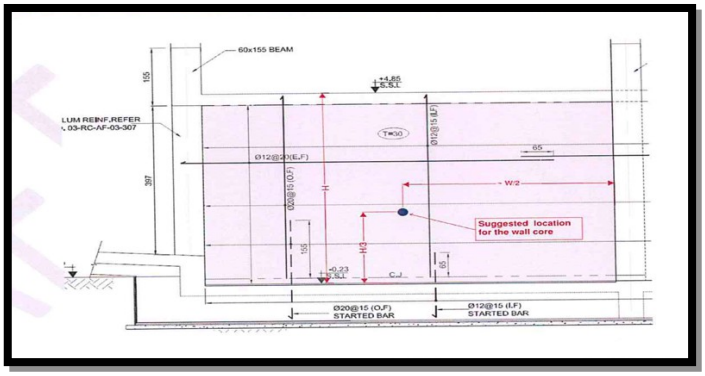


Figure 25:Typical location of core sample taken from a wall[3]

For the slab coring,drill the core within the 1.3 slab span in each direction

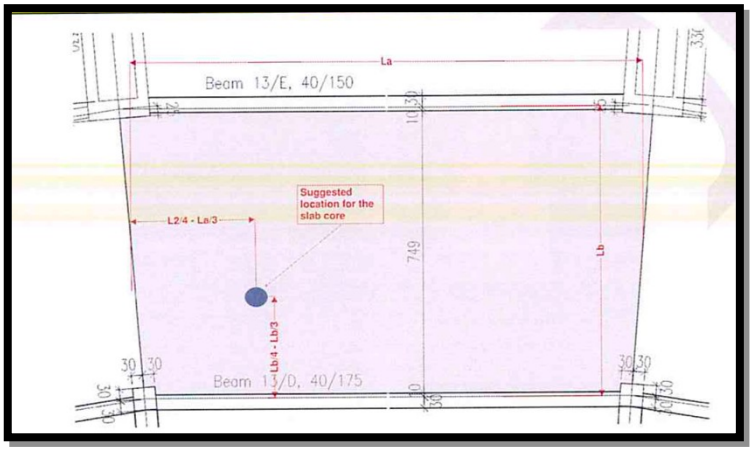


Figure 26:Typical Location of core sample taken from a slab[3]

To avoid the primary stress reinforcement at the bottom of the beam, beam coring positions should be in the middle of the beam span and in the middle of the beam height. The beam capacity will not be affected by zero or low shear forces on the beam in the mod span.

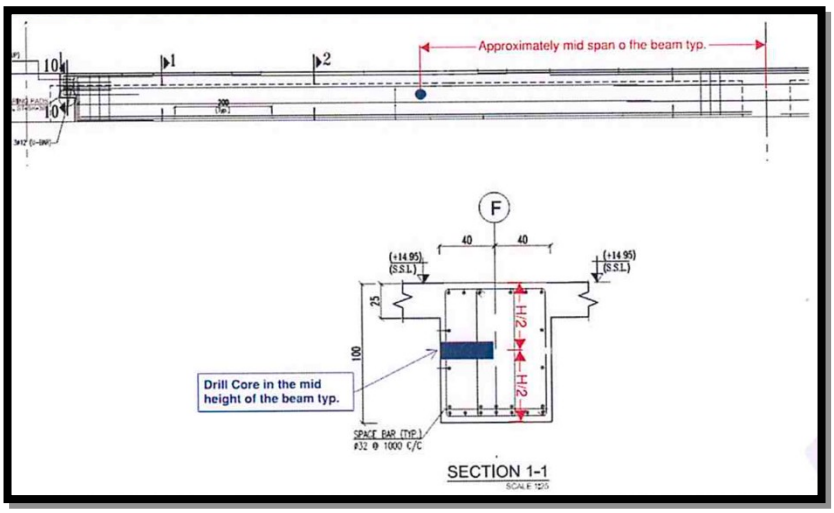


Figure 27:Typical Location of core sample taken from a beam[3]

Testing the cores is expected to yield the following information:

1. Corrected in-situ Cylinder strength
2. Density
3. Presence of cracks
4. Voids (%) & Honeycombing
5. Max aggregate size and distribution
6. Elastic Modulus E
7. Poisson’s ratio
8. UPV along the length of the concrete core.

3.4.2.5. Concrete Core Petrography Test

A petrographic examination is a test that can determine a variety of hardened concrete qualities. Typically, petrographic samples are made from core samples or test cylinders. The hardened concrete sample is cut, ground, and polished until the aggregates of the concrete approximate those of a granite countertop. After that, a microscope is used to analyse the polished surface at magnifications ranging from 10x to 60x on lapped sections and up to 400x on thin sections.
Chemically unstable minerals such as soluble sulphates, unstable sulphide that may form sulphuric acid or cause distress in concrete exposed to high temperatures during service, or volumetrically unstable components should be determined by comparing the discolouration of the cooled concrete.

Because of the conversion to beta-quartz at 573 °C (1063 °F) and the resulting volume increase, specifications may limit the quartz content of aggregates for use in concrete that may be exposed to high temperatures (purposefully or accidently).
Data from Thermogravimetric Analysis (GA) and Differential Scanning Calorimetry (DSC) will also be used to assess the temperature history of concrete after the fire. To determine some of the following properties, microscopic examinations are conducted in accordance with the applicable sections of ASTM C856 Standard Practice for Petrographic Examination of Hardened Concrete and ATM C1723 Standard Guide for Examination of Hardened Concrete Using Scanning Electron Microscopy:

1. Heating history through the concrete depth. Plot of thermal isotherms through the concrete depths at 100°C increments
2. Depth of damage to concrete caused by elevated temperatures
3. Alkali Silica Reaction and Carbonation
4. Chloride Ion content
5. Chemical Attack (Hydrochloride acid)
6. Aggregate type & composition, (Aggregate Mineralogy)
7. Aggregate Segregation
8. Consolidation
9. Density of Concrete
10. Water to Cement Ratio
11. Water Content/ Moisture Content
12. Permeability
13. Cause of Cracking
14. Corrosion of Reinforcing Steel
15. Type of Hydraulic Binder (cement)

Core samples are taken from both impacted and unaffected materials in order to establish a baseline against which the affected materials' results may be compared to the values of good/original material.
The current version of the APG SR2 code must be used to conduct a pyrographic evaluation of samples (A code of practise for the petrographic examination of concrete).

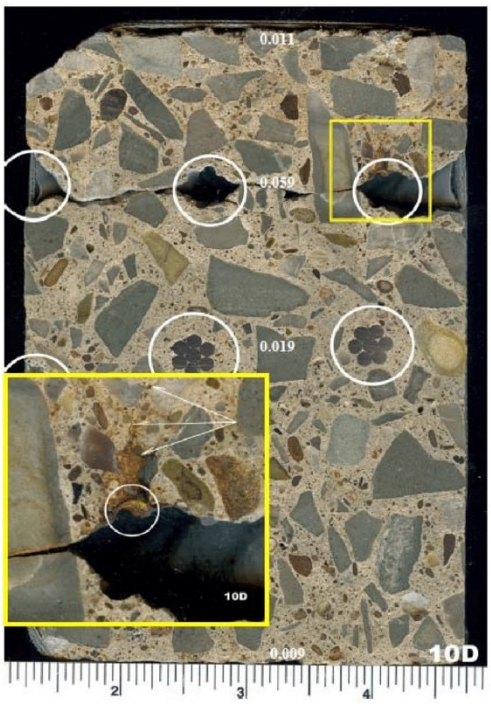


Figure 28:Petrographic core testing example[4]

3.4.2.6. Ultrasonic Pulse Velocity (UPV)

For more than 60 years, this test procedure has been used to determine the quality of concrete. Given the fundamental link between pulse velocity and dynamic elastic modulus, as well as the latter parameter's considerable temperature sensitivity, the application of the pulse velocity technique for the assessment of thermally damaged concrete is well established. The elastic characteristics and density of the concrete influence the ultrasonic pulse velocity through the concrete. As a result, this approach can detect areas with low density or poor flexibility, such as fire-damaged concrete. Because this test necessitates a flat surface, it is only suitable for unspalled surfaces. The test is carried out in accordance with ASTM C597 (Standard test method for pulse velocity through concrete).

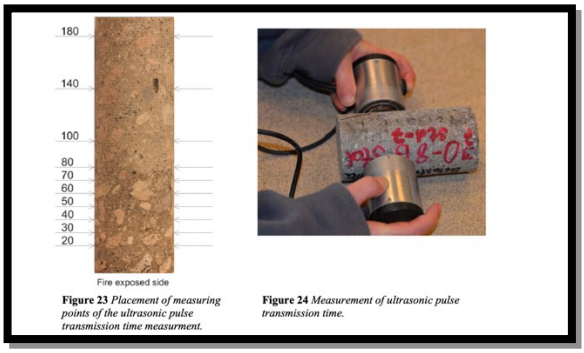


Figure 29:Direct UPV test[5]

Tests are carried out to gather the following data:

- The difference in quality between fire-affected and unaffected concrete when compared to excellent concrete.
- Particularly suitable for slabs and walls.
- Detection of cracks
- Delamination
- Presence of honeycombing
- Presence of voids
- Ultrasonic measurement on concrete cores along its length using point exponential probe transducers

Due to the Young's modulus's high temperature sensitivity, UPV is one of the most immediate markers of thermal damage. It is not capable of measuring concrete strength, but it has a better chance of comparing known/good concrete to the impacted concrete. The modulus of elasticity estimate for most practical concretes built with natural aggregates should be accurate to within 10%. The time it takes for an ultrasonic pulse to travel through the concrete being tested is measured using this method. When the concrete quality is good in terms of density, consistency, homogeneity, and other factors, a higher velocity is achieved. The following is a typical interpretation of the results:

Table 2:Concrete quality based on the resulted velocity from UPV

Longitudinal pulse velocity m/s	Concrete quality
>4,500	Excellent
3,500-4,500	Good
3,000-3,500	doubtful
2,000-3,000	Poor
<2,000	Very poor

The UPV is suggested for the following applications:

All concrete cores were removed from the fire-damaged concrete and measured along their lengths. The exponential probe receiver, with a tip diameter of 6mm, is the most useful for this type of test, making only point contact and usually requiring no surface treatment. The signal power available from a transmitting transducer of this type is so low that it is usually only appropriate for laboratory testing rather than on-site testing.

A UPV test is not required for cores retrieved from intact concrete.

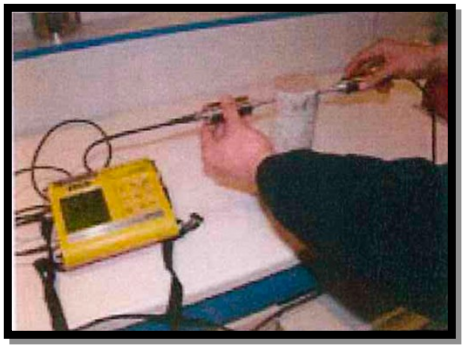


Figure 30:UPV scanning along the length of concrete cores[3]

The results are presented in the graph below:

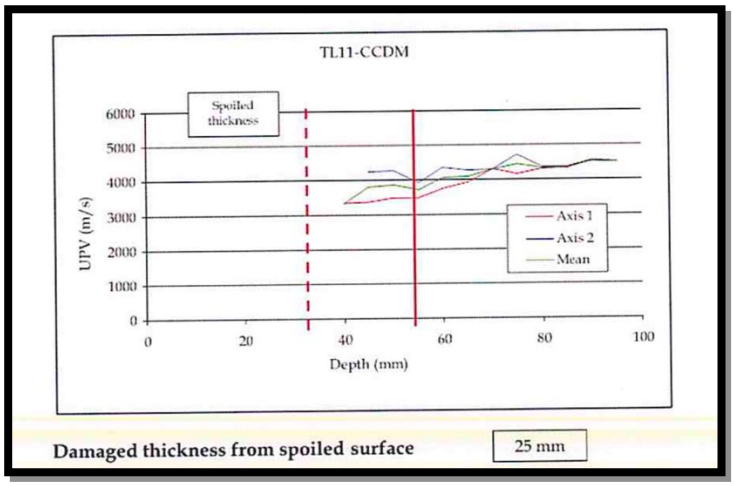


Figure 31:UPV core scanning result[3]

Every fire-damaged core is scanned along its length as part of the standard test procedure. Concrete having a UPV of less than 3,500 m/s should be removed, cored, and compressive strength evaluated.

The thickness of the damaged concrete on the structure element is determined by measuring the thickness of the concrete from the fire spoiled surface to the depth where the UPV is greater than 3.500 m/s, from which the core was extracted and must be removed before proceeding with the repair of the damaged element.

3.4.2.7. Reinforcement Mechanical Properties

A laboratory test programme on a number of reinforcement bars taken from the fire damaged elements; from locations directly affected by fire and locations apparently not affected by fire but on the same elements is proposed to determine the degree of damage to the steel reinforcement due to the elevated temperatures within the fire damage zone.

The following should be checked on the sample reinforcement bars:

- Yield Tensile Strength
- Ultimate Tensile Strength
- Elongation

This is a simple test designed to determine the reinforcement's mechanical properties. Extracting reinforcement samples from the structure elements indicated below is required; two samples of reinforcement are judged sufficient as described below:

- Walls (sample from vertical reinforcement and sample from horizontal reinforcement)
- Columns (samples of the main reinforcement and samples of links reinforcement)
- Slabs (sample from top reinforcement and sample from bottom reinforcement)
- Beams (sample from primary flexure reinforcement and sample from shear links)

Samples of reinforcement from the fire-damaged element and the undamaged element are supplied for each structure element.

This test should provide the following information:

- Size, diameter, etc.
- Weight per meter/foot
- Yield stress - Fy
- Ultimate tensile strength - Fu
- Percent elongation (bar only)

The most recent versions of the applicable ASTM A370, ASTM E6-09BE1, and ASTM E8/E8M standards must be used.

3.4.2.8. Concrete Slab Deformations Following the Fire Damage

Deformation measurements can be used to track the decrease of tension in pre-stressed structures. Following the fire event, a load test on the slab of The Address Residence - Fountain View – Dubai will be conducted. The goal of the test is to see how the slab reacts when it is subjected to the worst possible loading circumstances that could occur during the structure's service life. The scope of work was based on AC 318 M-14, "Strength Evaluation of Existing Structures," Chapter 27.
The test must be performed after the load-bearing section of the construction has been in place for at least 56 days. It will be possible to conduct the test at a younger age if all parties involved agree.

⇒ Load intensity

According to the data delivered by the client as per the designer's requirements:
Test Load (L) = 350 kg/ m2
Test Area = 76.5 m2
Total Required Test Load = 350 x 76.5 = 26775 kg
Total Required Cement Bags = 26775 / 50 = 535.5 Bags

Slab will be inspected after each load increment

⇒ Test Procedures

On-site, the following procedures should be followed:

- t the bottom of the slab, calibrated dial gauges should be fixed to measure the expected deflection. In the event of loading, five (5) gauges should be utilised to measure the deflection (asper the attached drawing).
- The gauges must be calibrated to a starting point.
- The contractor should take special precautions and safety measures to ensure that there are no vibrations in the testing area during the length of the test.
- Cement bags should be evenly dispersed on the slab by the contractor's labours according to the intensities mentioned in the loading cases.

- Apply the test load in five approximately equal increments.
- Each step increases the weight per square metre by 70kg/m2.
- Only lab technicians will have access to the area of the slab where the reading gauges will be put, to prevent reading gauges from being accidentally disturbed.

- After completing five loading increments, the slab should be loaded for 72 hours before taking deflection measurements.

- Deflection response measurements should be taken every hour for the first 24 hours, then every 6 hours for the remaining 72 hours of 100 percent loading.
- The slab will be gradually unloaded in five steps. After each unload step, the deflection must be measured 1 hour later. To determine residual deflection, final response measurements should be taken immediately after unloading and then again after 24 hours.

⇒ Reporting

All of the test methodologies, as well as the tabulated deflection and residual deflection measurements, will be detailed in the factual report. The structural engineer will do all essential analysis and interpretation of the test results.

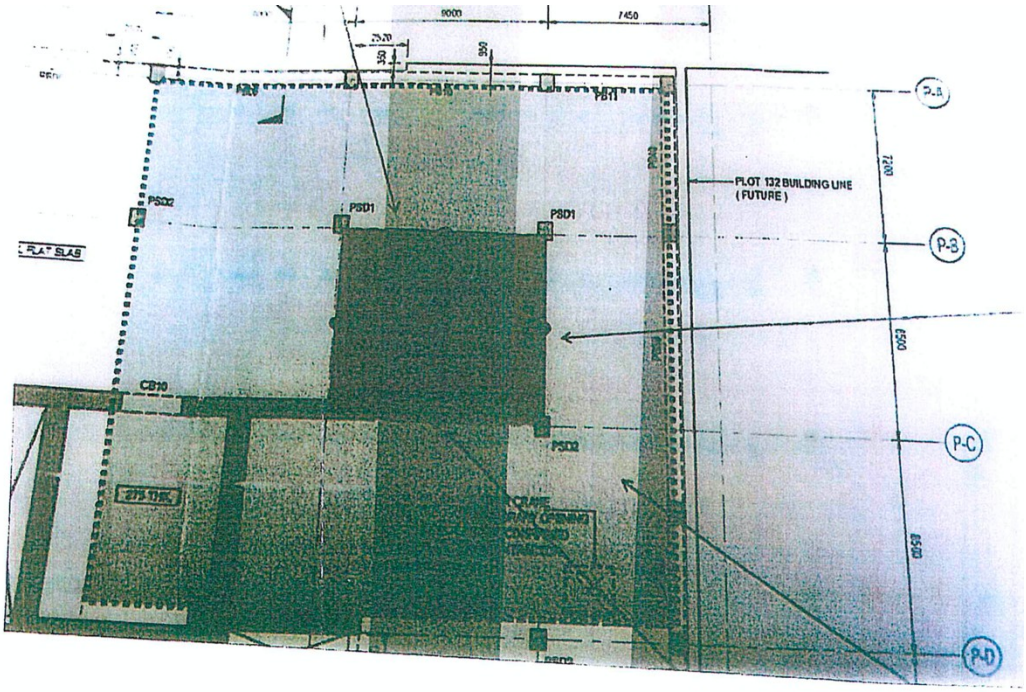


Figure 32:Plan view of the tested slab[5]

3.4.3. Removal of Damaged Concrete and Surface Preparation

The area of reinforcement within the structure that has to be repaired will be clearly marked and safeguarded from harm during the repairs. To establish the nature and degree of preparation required, the state of the substrate will be assessed, including unsound concrete, bond-inhibiting materials, substrate deterioration, cracking, and surface pollutants.

To a minimum depth of 10mm, cut around the perimeter with a saw. The cut will be perpendicular to the concrete face around it. There will be no "feather-edged" repairs. The concrete will be removed from the steel reinforcing bars' full diameter and a further 20-30mm beyond it, or as instructed by the design drawings. Using clean, oil-free compressed air, all dust and loose particles will be removed from the treated area. Where chlorides are suspected, the concrete and exposed reinforcing bars shall be carefully washed with clean water to ensure that any remaining contamination is removed.

Figure 33:Wall chipping of the daamged concrete[2]

3.4.3.1. Chipping and Surface Preparation

The current structure must be stripped of any loose, cracked, or otherwise unsuitable or substandard concrete. It is vital to ensure that the reduction in structural section will not have an influence on the member before proceeding with chipping. In some circumstances, it may

be required to remove any significant load carried by the member (e.g., equipment or plant) and reinstall it following restoration.

Where reinforcement is found, the concrete directly in contact with the reinforcement's sides must be removed to leave a 1-inch free space between the reinforcement and the in-place concrete.

Using electrical chipping hammers (SDS Max) and/or 15 lb pneumatic hammers, remove all damaged concrete to acceptable sound concrete.

Figure 34:Chipping hammer[2]

The surface preparation method will ensure that:

- The concrete surface is solid (not broken) and the reinforcement is unaffected by the surface preparation procedure (not damaged).
- Concrete is not weakened or loosened by vibration, impact, or construction loads.
- The possibility of micro/cracking being introduced during surface preparation is reduced.

3.4.4. Reinforcement installation

After the Column has been laid out, the dowels must be drilled to provide the requisite anchorage depth as described in the expansion details. Additionally, holes must be drilled into the slab to give bars with the necessary development length on adjacent floors. The hole will be filled partly with epoxy.

The reinforcing steel will be placed into the hole while being rotated slightly to ensure that the steel's outside is fully coated in epoxy resin. With some overflow from the hole, the epoxy substance should show from the surface.

3.4.5. Concrete Repair by Hand Application (Type 2 & 3 Vertical and Cosmetic Beam Repairs)

3.4.5.1. Repair Material application

A thixotropic repair mortar with the ability to bond in adhesion to the prepared surface of the parent concrete will be utilised for hand application of surface (skim coat) repairs.
Procedure

- Add all the components of the mix to the container
- Use an electric hand drill with an attached mixing paddle to thoroughly mix the components of the mortar together (at slow speed).
- Once the material is uniformly mixed, the speed of the drill will be increased for less than 1 minute to ensure that all of the material has merged in proportion.
- Using a hand trowel, remove the material from the container and apply it to the prepared area in 25mm lifts (Maximum number of lifts required to complete a repair section will be two).
- When the patch has reached "thumb-nail" hardness during the curing phase, a second lift will be applied until the patch is level with the surrounding surfaces.

For the repair mortar, a single (1) 50mmx50mm cube will be manufactured every batch (of bag material).

3.4.6. Pull-off testing

The in-situ drilled core tensile pull-off test is used to determine the strength of the repair overlay's tensile binding to the existing concrete substrate. Existing concrete, a bond interface, and repair material make up the new system. The ASTM C1583 in-situ drilled core tensile pull-off test method will be used.

3.4.6.1. Test Procedure

- A core bit is used to drill through the composite system
- A rigid disc is mounted to the top of the drilled core with high-strength glue.
- The testing equipment provides perpendicular tensile load to the core through the rigid disc.
- Tensile bond stress is reported as failure load divided by cross-sectional area of the core

3.4.6.2. Test Site Selection

The first round of testing will be carried out on the mock-ups of the wall and column. After obtaining satisfactory results, the repair should be carried out using the same materials and manner of operation. The test location must be free of delamination/de-bonding, embedded components such as reinforcing steel, post-tensioning tendons, and electrical conduits, among other things.

3.4.6.3. Coring

Drill a circular cut through the repair material and into the existing substrate, perpendicular to the surface. The cut should go into the existing substrate to a minimum depth of 25 mm or one-half the core diameter, whichever is greater.

The minimal depth into the current substrate for a 50 mm diameter core is 25 mm, while the minimum depth for a 75 mm diameter core is 40 mm. The core remains unaffected.

3.4.6.4. Rigid Disc Attachment

The rigid disc will be attached to the top of the drilled core using an adhesive .The rigid disc may also be attached to the test surface prior to coring, as long as coring shall not adversely affect or damage rigid disc installation.

3.4.6.5. Acceptance Criteria

Pull-off tests will be conducted on trial sample repairs in accordance with ASTM C 1583 in order to determine the optimal surface preparation process for ensuring a suitable bond between the existing concrete and the concrete overlay for repair operations.

Pull-off tests for sample repairs will be done at random locations within the area requiring strengthening after the surface preparation procedure has been agreed upon.

3.4.6.6. Mock-up test

Mock-up tests should be conducted independently on two regions that have been set aside for this purpose. For each region, a concrete overlay with a minimum thickness of 100 mm must be produced using the recommended concrete mix design.

Repairs are put to the test in the areas that need to be strengthened.

- For Columns – Every 150 sq. m of repair – Min. 3 Nos. test specimen required.
    - For Walls – Every 200 sq. m of repair – Min. 3 Nos. test specimen required.
    - For Slabs - Min. 3 Nos. test specimen required

Pull-off Strength Requirements Based on Trials

The pull-off strength determined through testing must meet the following requirements:

- C1: Mean of "n" results (TBS, mean), minimum 31.0 MPa

- C2: Any individual test result (TBS, i), 0.8 MPa

3.4.6.7. Acceptance of Test Results

The pull-off strength determined by the trials must be based on an average of 90% of the average trial specimen test results. Any specimen test with a result less than 75% of the average pull-off strength of the trial specimen results requires an additional specimen test.

The needed pull-off strength should not exceed the present substrate or repair material's tensile strength, whichever is lower.

3.4.6.8. Test for Drying Shrinkage of Concrete

Concrete drying shrinkage should be measured using the ASTM C157 / C157M - 08 technique. For each test condition, three specimens must be prepared using this approach.

The minimum number of shrinkage tests necessary is: three tests

The drying shrinkage after 28 days should be less than 0.025 percent (250- strains) for a water/cement ratio of w/c 0.45.

Test for Compressive Strength

Test core specimen obtained from finished works for compressive strength in accordance with ASTM C 39.

3.4.7. Concreting Using Form & Pump and Form & Pour Techniques (Type 1 Verticals & Beam Repairs)

The procedural criteria for structural concrete repair with formed and pressure pumped concrete are included in this section.

3.4.7.1. Concrete Pumping

Using a 2" or 4" line system, the concrete will be pumped into the formwork from ports and valves.

All trucks transporting material to site or batches of micro concrete mixed on site will be examined and checked at the pumping station before being pumped (or associated testing area). The following necessary criteria will be examined.

Table 3:Concrete characteristics

Slump flow	minimum 650mm acceptance
T-50 time	maximum 3.5sec acceptance
Visual segregation	0~1 accepted only
Concrete cubes	compressive strength
temperature	As per site acceptance levels
Time from batching	Up to 150 min from batching

Figure 35:Pumpimg system[4]

Depending on the climate, To balance the temperature of the final mix, use ice or cold water. The Pump hopper will then be filled with properly mixed concrete (bag-mix). Micro-concrete will often travel steadily across the bottom of the form before rising evenly. Both air and wet-leading edge of grout will be pushed out of the bleed holes as the concrete material begins to fill the form. Only when a sufficient amount of aggregate has been ejected from the section will SPME close bleed holes. The pumps will keep going until the forms are completely filled and pressured.

Testing cubes (100mm x 100mm) will be given at a rate of two tests every 1000 bags of concrete utilised. The frequency per volume is — 2 sets every 12 cubic metres, with each bag carrying 0.42 cubic feet of material (or two tests per tractor-trailer truck of material brought in). One test per typical ready-mix concrete truck is also the equivalent.

Two sets of four cubes will be broken at 3, 7, and 28 day intervals in the tests. One cube will be maintained in case additional testing is required in the future.

3.4.7.2. Stripping of Formwork

After the concrete has reached 75% of the design compressive strength, but no earlier than 3 days, the formwork can be removed.

The structure will be treated with a curing chemical (Master Kure 181) that will be sprayed or rolled on. Curing compound can be left on the structure as long as it doesn't interfere with subsequent finishes.

3.4.7.3. Concrete Application – Shotcrete

Operating Requirements - Because guniting is a sprayed concrete application, it necessitates the use of greater pressure air. To run the Shotcrete machine, the compressor should have a minimum capacity of 375-400 cfm and a minimum pressure of 45 psi in the Gun chamber for proper placement and enough bow-out jet needs.

Site Setup

The site will be set up in such a way that the sprayed concrete may be applied as quickly as possible. Based on a maximum pumping length of 30 m and a vertical pumping height of 30 m, the pump will be placed in the most acceptable location (for example, in the corridor outside the rooms with fans for ventilation and the hoses will be moved through the service shafts). A compressed air supply with a flow rate of 400 cfm and a minimum pressure of 6 bar close to the nozzle will be required. This will be taken into account in the air supply arrangement. Various tools, blow out heads will be kept with the pump.

- ⇒ Application

Prior to beginning the gunite procedure, the prepared concrete surface must be saturated in water on a regular basis. The method will consist of spraying water four (4) times in the hour preceding up to the substance application. The wetted surface should resemble the current concrete's Saturated Surface Dry (SSD) condition.

Starting from one side of the prepared area, the nozzleman should complete the material build-up with repeated spray passes.

The nozzleman will examine and control all uniformity (including the w/c mix ratio).

Every shotcreting procedure will include the preparation of a test panel measuring (600 x 600 x 100) mm. A total of 12 core or cube samples from the panel will be cut/taken and evaluated at 3, 7, and 28 days. One set (3 no.) will be preserved in case extra testing is required in the future.

The concrete will be made specifically for use in shotcrete applications. After the material has cured to "thumb-nail" hardness, any finishes to fit the site specifications (as per Engineer) will be applied.

⇒ Curing

As soon as the appropriate portions have been surface finished, curing compound will be applied. Complete coverage will be ensured, especially around the contact with the host concrete.

Using a spray application or a 14-nap roller, a curing compound will be applied to the repaired area.

After 28 days, the concrete should have reached its maximum design strength.

3.4.8. Repair of Cracks

The Equipment needed for repairing cracks is:

- Concrete breakers with adequate bits and grinders with concrete cutting/roughening disc
- Air blower
- Rotary hammer
- Mixing paddle machine
- Injection packers

- Injection pumps
- High pressure air compressor

Crack repair can be done in two ways: one using epoxy injection, and the other utilising grouting and sealing.

Epoxy Injection

Epoxy injection is commonly used to connect cracks as small as 0.05mm. Establishing entrance and venting apertures at regular intervals along the fractures, sealing the crack on exposed surfaces, and injecting the epoxy under pressure are the basic steps. Epoxy injection has been used to repair fractures in buildings, bridges, dams, and other concrete structures with great effectiveness (ACI 503R).

This procedure is not applicable if the fractures are actively leaking and cannot be dried up, with the exception of certain moisture-tolerant epoxies.

Figure 36:Epoxy injection until refusal[2]

⇒ Procedure

The technique generally consists of:

- Cleaning the gaps of any grease, oil, dust, leftover curing material, or pollutants that could impede injection port adhesion is usually the first step.
- Crack sealing on exposed surfaces
- Installing entrance and venting openings at regular intervals along cracks with a diameter of 6-10 mm and a length of 50-75 mm into the concrete element.
- Mixing the epoxy.
- The cap seal must be correctly placed because the epoxy will be contained as it is injected under pressure. Check for resin coming out of the next hole along the way as you inject from the lowest or farthest point towards the centre. Continue to inject until you get a refusal.
- Taking off the surface seal

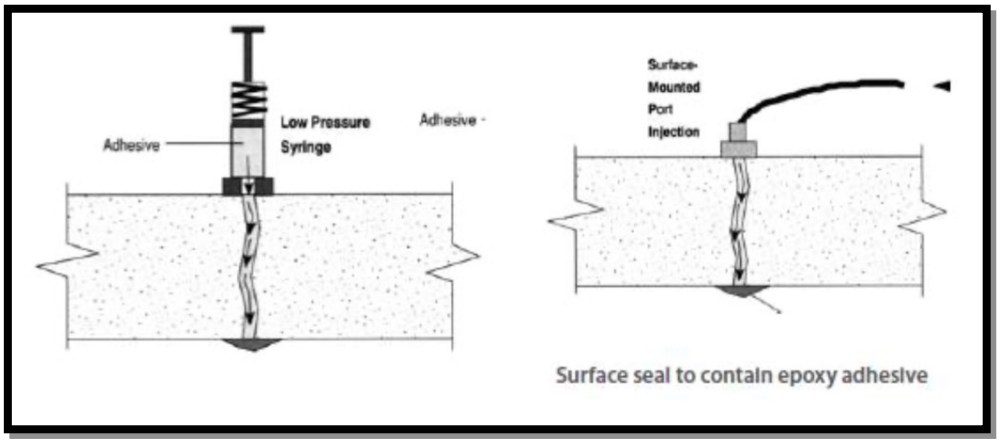


Figure 37:Epoxy injection process[1]

Figure 38: Real epoxy application[1]

3.4.8.1. Routing and Sealing

Routing and sealing cracks is utilised in situations where structural restoration is not required and the crack width is less than 0.3mm.

This approach entails:

- Preparing a vertical walled groove at the surface, typically varying in depth from 6 to 25 mm, to enlarge the fracture along its exposed face. It's possible to use a concrete saw or a right-angle grinder.
- The groove is next cleaned and dried, either by air blasting, sandblasting, or water blasting.
- In the dry groove, a sealant is applied and allowed to set.

- Finally, fill the vertical-walled groove with a high-viscosity, hard epoxy or apply MasterBrace ADH200 uniformly across the surface with a towel or spatula.
- Over-banding (strip coating) is sometimes used instead of or in addition to routeing and sealing to achieve a waterproof repair in 30 to 45 minutes.

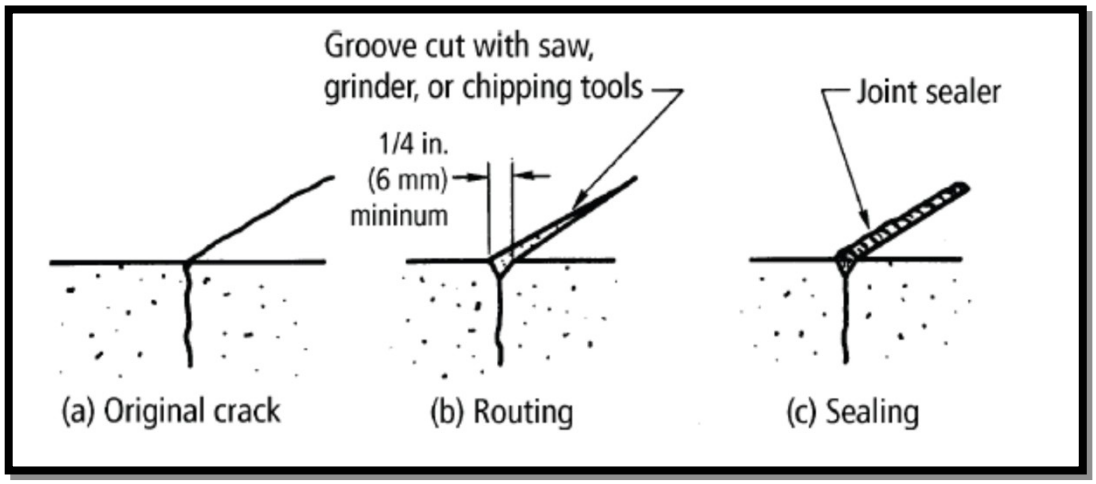
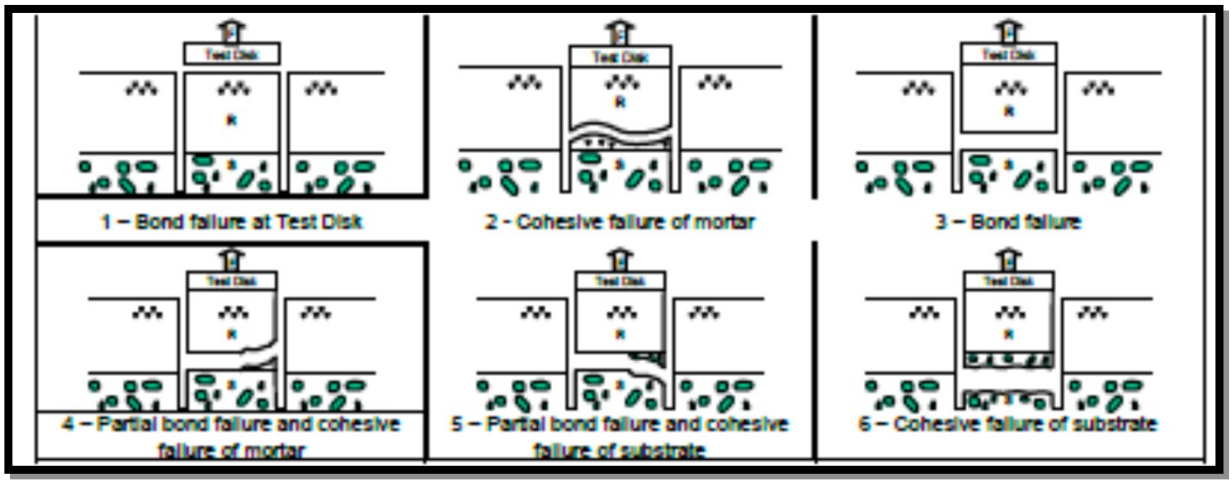


Figure 39:Routing and sealing process[2]

Perform cores on random spots after the repairs have been hardened for a minimum of 28 days and as advised by the Consultant to ensure intimate contact between the old and new concrete. This will also reflect the repair quality and any voids, if any.


1 – Bond failure at Test Disk
2 - Cohesive failure of mortar
3 – Bond failure
4 – Partial bond failure and cohesive failure of mortar
5 – Partial bond failure and cohesive failure of substrate
6 – Cohesive failure of substrate

3.4.9. Spalled Concrete Repair

The repair order will be determined by the damaged area, exposed steel, and damaged steel...

There are three different sorts of damages:

1) When existing reinforcement is visible but unharmed.

2) When existing reinforcement is exposed and deteriorated.

3) If the reinforcement isn't visible

Figure 40:Spalled concrete on the column[1]

Figure 41:Spalling observed on site[1]

Before beginning chipping on the first and second types, the slab under the spalled area must be supported.

1. Repair For the 1st type

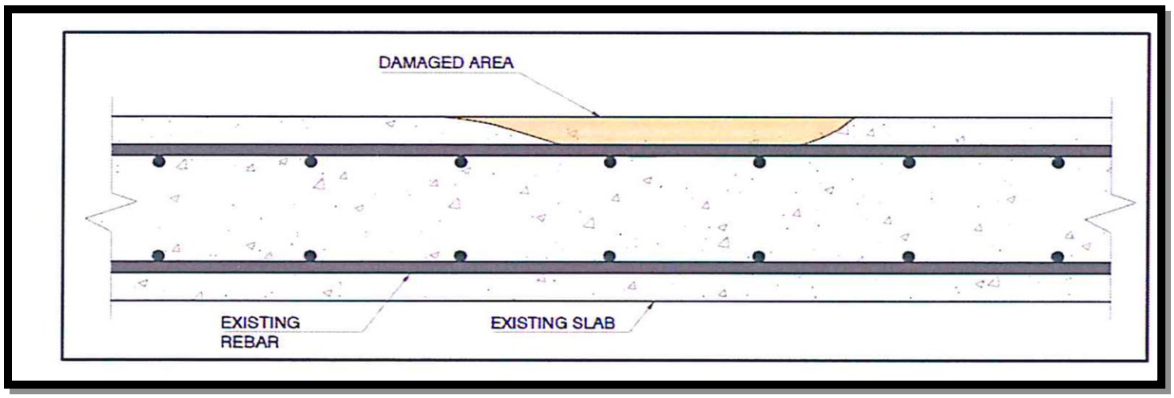


Figure 42:Spalling area without damaged rebars[4]

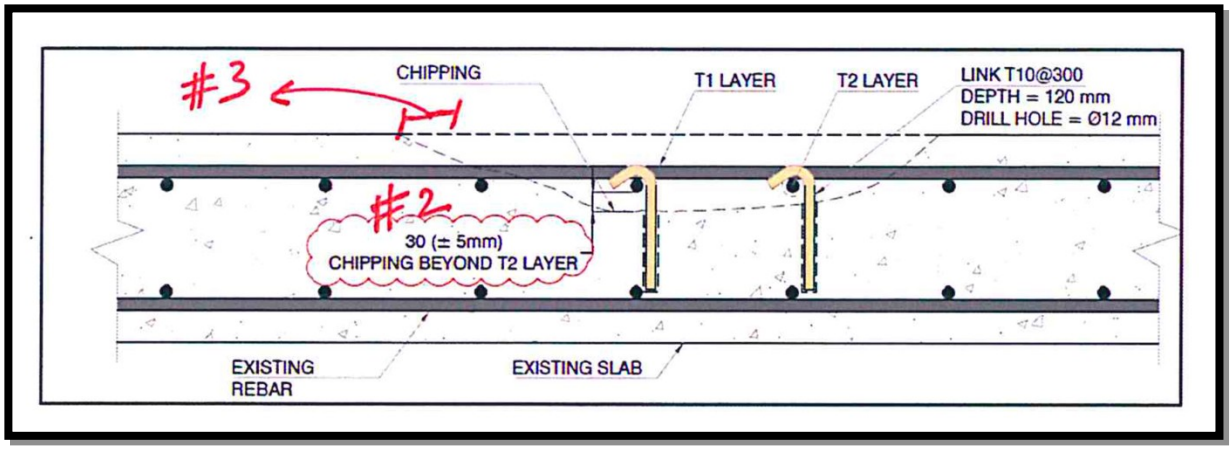


Figure 43:Chipping and installation of links[4]

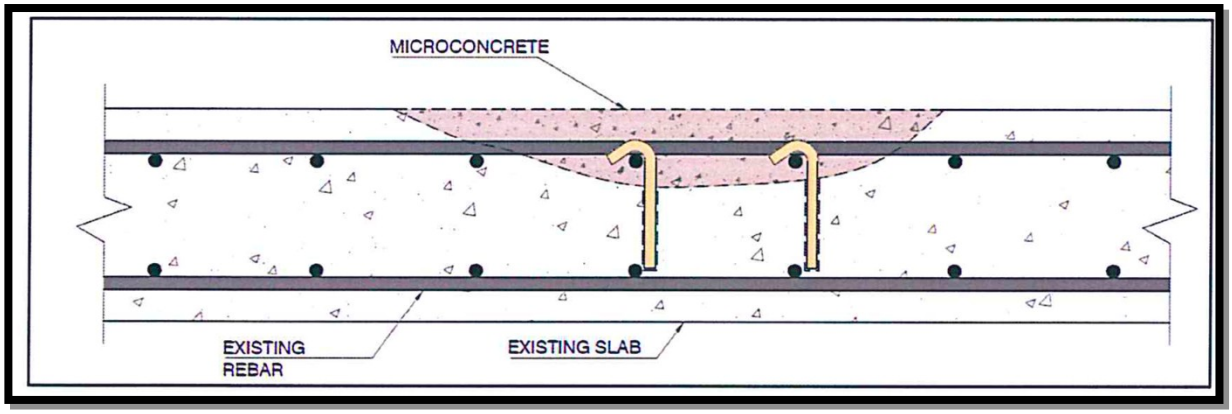


Figure 44:Casting on new micro-concrete[4]

2. Repair For 2nd type

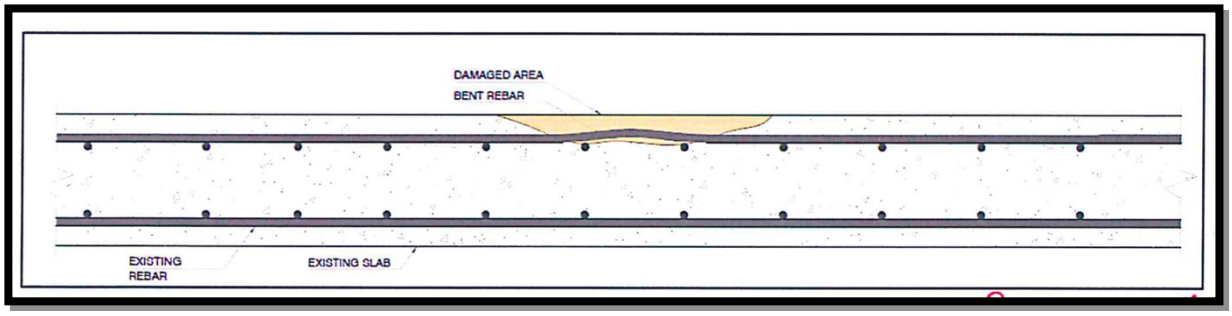


Figure 45:Spalled are with damaged bars[4]

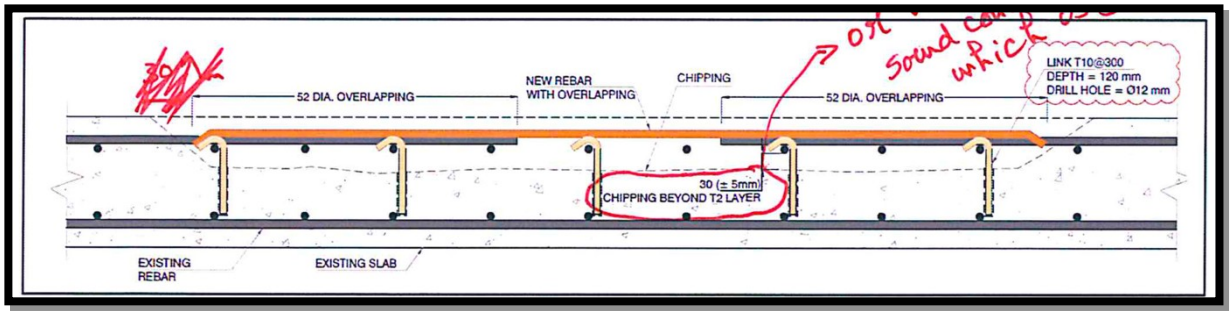


Figure 46:Chpping and installation of new rebars[4]

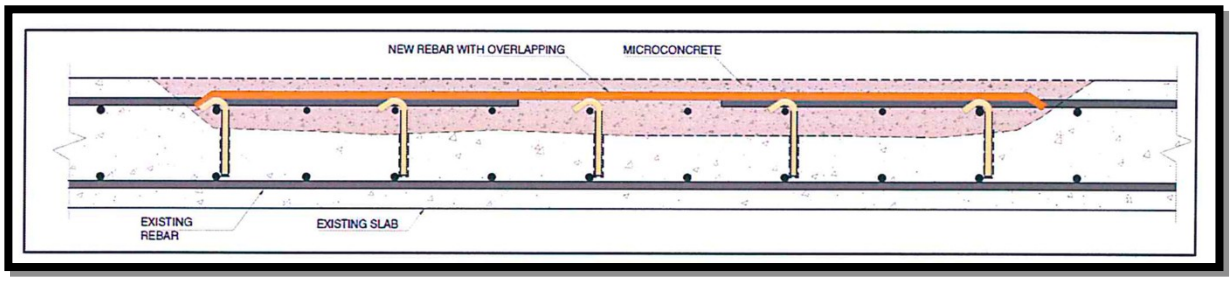


Figure 47:Casting on new micro-concrete[4]

3. Repair for 3rd type

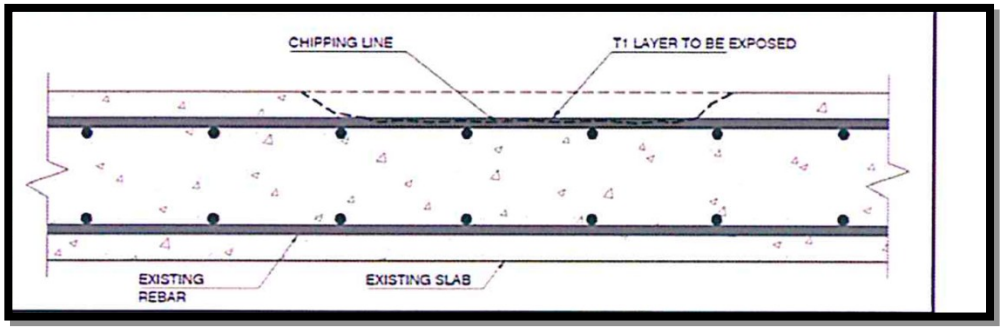


Figure 48:Spalling area without exposed rebars[4]

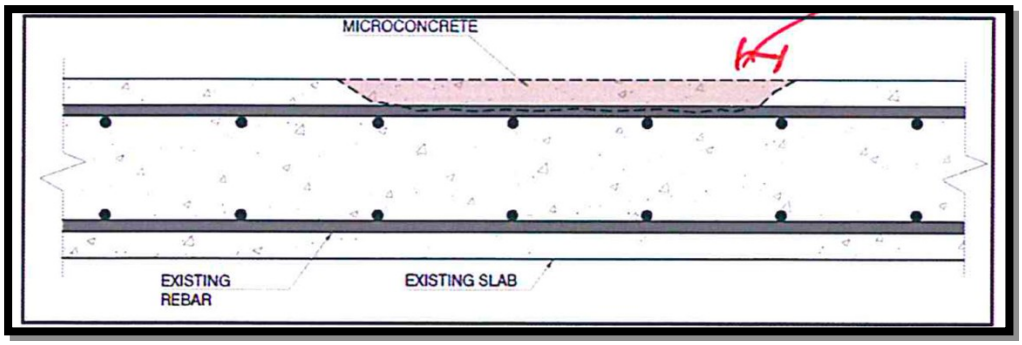


Figure 49:Chipping[4]

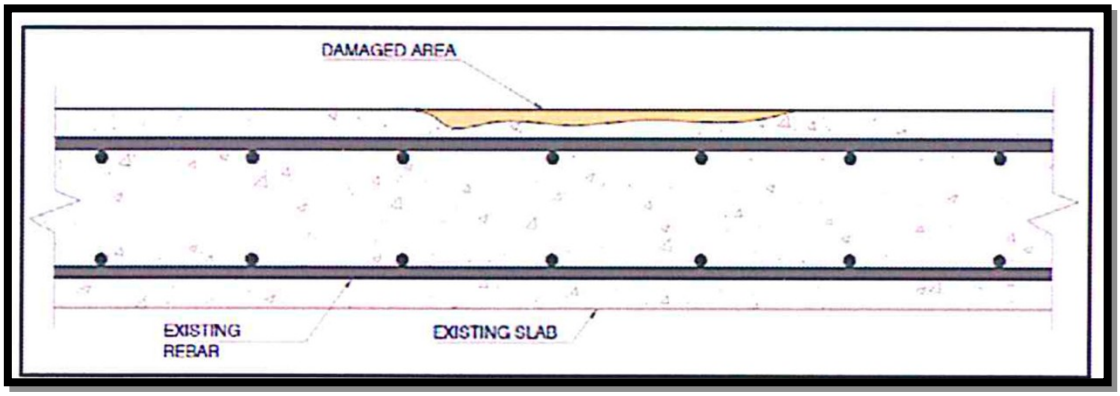


Figure 50:Casting of new micro-concrete[4]

Figure 51:Spalled concrete wall[4]

3.4.9.1. Chipping

A boundary of 50 mm beyond the designated line will be added to the chasing off of impacted concrete. To generate uniform clean edges, a marking line will be cut with a diamond disc grinder. cutting line to be cut at a 45-degree angle Cover concrete will be chipped to expose T1reinforcement layer if existing reinforcement is not visible.

3.4.9.2. Casting of micro-concrete

3.4.9.2.1. Mapegrout ME05

Mapegrout ME05 is a high-flow, shrinkage-compensated micro-concrete and thick section grout with a high performance.

When should you utilise it?

For gaps up to 220 mm, utilise a high-flow micro-concrete or grout for concrete structural repairs where the thickness and void configuration necessitate it.

Mapegrout ME05 is a pre-blended powder made up of selected cement, aggregates, and unique additives that is shrinkage compensated and made according to a formula devised in the MAPEl research labs. When mixed with water, Mapegrout ME05 forms a fluid micro-concrete and thick section grout that can be poured or pumped into formwork without segregation. Please keep in mind that Mapegrout ME05, like all other high-quality cementitious-based materials, requires curing.

Once cured, Mapegrout ME05 exhibits the following properties:

- High flexural and compressive strength
- Modulus of elasticity and coefficients of thermal expansion and permeability to water vapor similar to those of high quality concrete;
- The expansion of mapegrout me05 has been calculated to compensate for hygrometric shrinkage.
- Low water permeability
- High bond strength to new and old concrete substrates, providing the substrate has
  been saturated with potable grade water beforehand and high bond

to reinforcing bars

- High abrasion resistance

⇒ Technical data

Table 4:Technical data of Mapegrout me05

PRODUCT IDENTITY	
consistency	powder
colour	grey
Maximum aggregate diameter(mm)	4
Density(kg/m3)	1650
Dry solid content(%)	100
APPLICATION DATA	
Mixing ratio	one 25 kg bag of Mapegrout ME05 with 3.1-3.3 litres of water
Consistency of the mix	fluid
Density of mix(kg/m3)	2200
PH	12.5
Application temperature range	from +5°C to +50°C
Setting time	1 hour @ 23°C
Application thickness(mm)	15-220
FINAL PERFORMANCE	

Mechanical characteristics: Compressive strength (kN/m2): After 1day: After 7 days: After 28 days:	 30,000 55,000 Min 65,000
Mechanical characteristics: Flexural strength (kN/m2): After 1day: After 7 days: After 28 days:	 6,000 9,000 10,000
Drying shrinkage according to ASTM C157-93:	< 500 microstrian

3.4.9.2.2. Surface preparation

- Remove any loose or degraded concrete until the substrate is completely solid.
- All debris, cement laitance, grease, oil, and any coatings must be removed from the concrete substrate using high-pressure air.
- Pre-soak the substrate with clean, drinkable water, then remove excess water and free-standing water to create a saturated, dry surface before pouring the combined mixture.

3.4.9.2.3. Preparing the mortar and mixing

Fill a forced action concrete mixer with 3.1-3.3 litres of pure potable grade water. While the mixer is running, slowly pour in the Mapegrout ME05 powder and mix for 2 minutes, or until the mixture is fluid and free of lumps.

A slow speed drill (300 rpm) with a suitable mixing paddle can be utilised, depending on the quantity being made.

The material will be put directly onto the roughened surface after it has been mixed.

Chapter 4 Recommendations and Conclusion

Natural fire resistance is high in reinforced concrete structures. They are usually not totally destroyed when exposed to high temperatures. During the course of a fire, it was discovered that the most substantial concrete deterioration occurred in the near-surface layer. When examining structures after a fire, it's especially vital to figure out how thick the exterior cross-section layer is when the concrete is so badly damaged that it needs to be Chipped.

Following the completion of the fire damage assessment at the Fountain View Residence and receipt of the lab's final results, certain recommendations will be made to meet the requirements for any repairs:

- Throughout the restored structure's planned service life, the repair must prevent corrosion from attacking the reinforcement.
- The repair material must be as long-lasting as the restored material.
- The repair must restore the appropriate load bearing capability and assure that deformations are acceptable.
- The repair should guarantee that the building is fire resistant as necessary.

Make a map of the visible damage to the concrete structure, such as spalling, cracks, delimitations, deformations, and other fire-related affects. Alternatively, in order to restore the structure to its pre-fire condition, a fully new structural study based on current rules could be conducted.

Chapter 5 Reference

[1]Arabian construction company,2017,Method statement for drilling cored specimens from hardened concrete at fire affected areas at tower FV1

[2] Arabian construction company,2017,Method statement for repairing of spalled concrete and cracks repair ete at fire affected areas at tower FV1

[3]Burohappold Enginnering,2017,Materail testing and survey specifications

[4]Arabian construction company,2017,Method statement for Fire damaged concrete repaires and strengthening at fire affected areas at tower FV1

[5]Arabian construction company,2017,Method statement for Slab load test at fire affected areas at tower FV1

[6] Nepomuceno, M., & Bernardo, L. (2019). Evaluation of Self-Compacting Concrete Strength with Non-Destructive Tests for Concrete Structures. *Applied Sciences*, *9*(23), 5109. doi: 10.3390/app9235109

[7] Wróblewska, J., & Kowalski, R. (2020). Assessing concrete strength in fire-damaged structures. *Construction And Building Materials*, *254*, 119122. doi: 10.1016/j.conbuildmat.2020.119122